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METEOROLOGICAL INTERACTIVE DATA DISPLAY SYSTEM (MIDDS)

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ABSTRACT

A project has been implemented to fabricate, deliver, and install a Meteorological Interactive Data Display System (MIDDS) at the United States Air Force's (USAF) Cape Canaveral Forecast Facility (CCFF), Cape Canaveral AFS (CCAFA), Florida. The MIDDS system will ingest special mesoscale meteorological data sources; merge them together into a gridded data base composed of satellite, radar, and conventional meteorological observations; integrate the data into forms where they can be displayed alone or in conjunction with correlative data; and then display the required meteorological information quickly and easily for use by the CCFF forecasters. The MIDDS, a joint NASA and AF project, will significantly improve current capabilities, particularly during Space Shuttle landings where improved 0-3 hour mesoscale forecasts are required.

INTRODUCTION

In FY 84, the launch rate for the Space Transportation System (STS) increases dramatically to almost one per month. In order to maintain a high launch rate, unnecessary delays must be avoided and the environment poses many potential delays. The present risks associated with current weather prediction capabilities can lead to diverting missions from a J. F. Kennedy Space Center (KSC) landing. This results in 8-10 days delay in Space Shuttle processing, impacts on future missions, and results in millions of dollars of additional expense. The MIDDS is a system designed to provide the necessary hardware and software to improve weather support to Shuttle operations as early as the spring of 1984. The need for improved meteorological guidance exists on two scales. First, the mesoscale, where the time period 0-3 hours is important and, second, the synoptic scale, where the time period 12-48 hours is important. The mesoscale problem is directly related to the success of specific weather sensitive operations: rollout, launch and particularly landing. As such, frequent, high density, quality observations are needed to rapidly and accurately identify and forecast potential weather constraints so that these short term operations can be conducted in a safe yet cost-effective manner. The synoptic scale forecast improvement addresses cost-effective planning and scheduling of weather sensitive opera-

tions one to two days in advance.

Meteorological guidance will probably never be 100% reliable. However, significant improvements to current capabilities are possible and have the potential for saving the Shuttle program from unnecessary, costly delays on one hand, and possible lightning or other weather related damage to the vehicle on the other. It makes good sense for the functions that support a state-of-the-art system such as the Shuttle to have available state-of-the-art systems to provide that support.

PROBLEM

The environmental sensitivities of the Space Shuttle have increased the spacial and temporal preciseness with which many meteorological parameters must be forecast. In the past, extraordinary efforts on the part of weather support personnel managed to get the job done, but the increased mission frequency and the advent of KSC as a primary recovery site exceeds the capabilities of a manual system. New techniques and data are needed. The existing Cape Canaveral Forecast Facility (CCFF) instrumentation is a collection of independent weather sensors and/or display systems whose outputs have to be analyzed, interpreted and integrated by the CCFF personnel into a weather forecast. This is both a time consuming and an extremely labor intensive problem. The need to provide environmental support in a routine, nonlabor intensive manner for both launch and landing at KSC and Vandenberg Air Force Base (VAFB) was underscored by the failed KSC landing attempt during STS-7 and the experiences with clouds and thunderstorms during the STS-8 night launch. Even the good weather, with concerns about fog, for the historic 41-B (STS-11) first landing at KSC demonstrated the critical role of meteorological information.

METEOROLOGICAL INTERACTIVE DATA DISPLAY SYSTEM (MIDDS).

It is to specifically address these data integration problems that the University of Wisconsin's Space Science and Engineering Center (SSEC) was contracted with to develop a Meteorological Interactive Data Display System (MIDDS). The MIDDS is to be used by the CCFF to integrate the data from the many special meteorological data collection systems used to support the Eastern

Space and Missile Center (ESMC) mission and particularly the Space Shuttle sensitivities. MIDDS is an outgrowth of Joint KSC and ESMC planning and is based on the SSEC Man-computer Interactive Data Access System (McIDAS) philosophy. Its installation will be a major step toward the development of a real time data handling, analyzing, intercomparison, and display system for all available data sources.

Need. The CCFF provides 24 hour forecasting support for KSC and CCAFS to support their missions. The CCFF uses a variety of sophisticated pieces of equipment including radar, sixteen instrumented towers, atmospheric electricity (34 electric field mills) and lightning detection systems, upper air and surface measurement systems, satellite images, computer services, and a closed circuit television briefing system. During critical weather situations, the forecasters cannot manually fully assimilate all the huge volume of rapidly changing weather data in addition to carrying out their briefing responsibilities. The coastal marine environment presents many complex prediction problems because of the local small scale influences and interactions between the sea breeze, individual thunderstorm dynamics, and the national and regional scale weather systems.

An interactive graphics information system which could quickly and easily integrate all of the observational data was vitally needed at the CCFF. The major goal of the MIDDS is to meet that need through an automated data base management and interactive display. The presentation and interpretation of meteorological data using this system should reduce the time needed to evaluate weather situations and increase the precision and accuracy of the resulting forecast. Using a high quality video and graphics display terminal, the forecaster can view data from multiple sources on a single display screen, view these data in time sequences under his control, and interactively interrogate other data for additional information.

Selection Factors. A number of factors were involved in developing the MIDDS with pacing elements being cost, time, and a need for low development risk since the need for improved weather information was critical to the Shuttle landing program. The criticality was due to the extremely tight requirements for accurate knowledge of weather conditions along the Orbiter landing approach. For example, the vehicle can't fly within five miles of a thunderstorm or through even light rainfall because of danger of severe damage from a lightning strike, turbulence or erosion of thermal protection tile by raindrops. The development risk is low in MIDDS since it takes advantage of fifteen years experience by the contractor as well as three years of practical experience in development of an operational system, called the Centralized Storm Information System (CSIS), used extensively by the National Severe Storms Forecast Center to improve their weather advisories and warnings. The MIDDS

system could be quickly operational since it uses current operational software (the basic package has over 450,000 lines of proven code) and all major hardware components have been thoroughly field tested and proven. Basically then, the system uses "off the shelf" components.

With this concept, there will be no initial major development costs incurred by the government for these items since they were developed in the course of other government contracts. Further development costs are also minimized by taking advantage of similar on-going development and research programs at places like NASA's Marshall Space Flight Center, NOAA's Environmental Research Laboratories and the National Severe Storms Forecast Center. Since MIDDS hardware/software is the same as the SSEC's system, software development/conversion costs can be kept to a minimum and improvements incorporated into the "mother" system can be fully checked out and certified prior to installation in the CCFF on line equipment. Also, since Marshall Space Flight Center (MSFC) already has an SSEC terminal in use for their research programs, internetting the two locations becomes possible. This would provide MSFC access to unique CCFF data sets, enhance their atmospheric research on Shuttle critical mesoscale features, and facilitate rapid technology transfer to the day-to-day operational arena.

Benefits. Given all of the display and analysis capability of MIDDS, one of the most significant operational benefits will be in the displaying and use of satellite data. A local Geostationary Operational Environmental Satellite (GOES) earth station will provide CCFF forecasters with near real time imagery (replacing hour old data) and provide flexibility in image enhancement. The MIDDS will enable the forecaster to do three dimensional analysis of weather systems using visual and infrared (IR) satellite data plus rawinsonde and satellite derived atmospheric temperature profiles. In addition, image enhancement and animation will allow forecasters to better analyses and understand upper air dynamics. Flexibility such as this makes the satellite a truly real time data source. This, coupled with the ability to superimpose other data sets and analysis on the imagery will enable the forecaster to truly integrate a wide variety of special data sets and enhance their forecast products. The MIDDS should lead to better productivity and a lower false alarm rate for warnings and advisories issued for KSC and CCAFS. The forecaster will be able to monitor more areas of responsibility simultaneously. Since the presentations will have a higher information content, the forecasters will spend less time integrating data and more time understanding what's happening with the weather. Having a computer to help organize the forecaster's work, remind them of the status of their forecast products, and keep them up to date in rapidly changing weather situations such

as those encountered in dealing with thunderstorms. Thunderstorms have a life cycle of around one hour and may not even be seen by weather radar when critical on-orbit decisions must be made three or more hours before the actual KSC Space Shuttle landing. During landing the orbiter must transverse the highest area of thunderstorm activity in the United States and one of the highest areas of thunderstorm activity in the world. Thus, short range thunderstorm forecasting is critical to a safe mission and to preserving the increasing mission rate. Another benefit of the MIDDS is that the lessons learned from the CSIS program are incorporated into the basic software. While many of the lessons learned are specific to the operational environment of the National Severe Storms Forecast Center, there are several which are relevant to the MIDDS system. A "bottom up" design management philosophy is one lesson learned that has shown to be very effective. Requests, ideas, complaints, etc., are collected, prioritized into a "wish list" and passed on to a design team at SSEC. The system is then added to, changed, or modified according to the needs of the user. This allows for tailoring of the MIDDS to locally unique data sets and the particular mission requirements of the CCFF. The evolutionary "bottom up" design philosophy is also envisioned to allow the system to evolve in response to the individual forecaster's needs and desires, and result in improved system efficiency and acceptance.

With the advent of MIDDS, the CCFF will possess the equipment necessary for the operational testing of many models and forecast algorithms. Program managers are particularly interested in improved forecasting techniques of individual thunderstorm cells, where will they form, where will they move, and when will they dissipate. Current techniques are too crude to effectively meet the requirements of an active Shuttle launch rate. Considerable research in the meteorological community is being done to understand thunderstorm and mesoscale dynamics, but little is being done to focus this research on the specific Cape Canaveral thunderstorm forecast problem. Typically, models require real time access to high resolution (radar, mesonet, satellite), high frequency (5 minute interval) digital data and the ability to superimpose conventional and remotely sensed data. MIDDS will have these capabilities and will make these unique data sets available to the scientific community through the KSC as a mechanism to improve basic meteorological understanding and enhance forecasting techniques. Individual scientists will benefit by being able to test and develop their concepts and the Shuttle program support will benefit by having a means for rapid technology transfer.

Implementation Concept. The implementation concept of the MIDDS is determined by mission needs, budget constraints, and requirements for operational redundancy. The mission needs demand a state-of-the-art interactive system ingesting a multiple number of data sources and using an

integrated data base management and display technology. Thus, a three phased implementation plan was developed. Phase Ia was installed in March 1984. It is a basic remote terminal consisting of a single work station with its assorted support equipment. This will allow forecaster familiarization training to take place prior to the delivery of the entire first phase. The second part of Phase I will add a single embedded computer in August 1984. The system will interface to the local data acquisition systems and support the operational mission of the CCFF. The initial phase will not be fully operational in that it will lack redundancy and will require that some processing be done on other computers at the CCAFS. The initial system will provide a proof of concept by supporting most of the CCFF mission. In order to minimize costs, the initial system will lean heavily upon the existing SSEC software architecture with only limited modifications to accumulate the local data sets.

The second phase will consist of a gradual increase in the system capabilities and tailoring to meet the specific needs of the CCFF. These will consist of transferring models and forecast algorithms from developmental programs, and consolidating Eastern Test Range (ETR) programs as the ETR computers become saturated. The second phase will also include acquiring additional reception capability for satellite data and adding additional work stations. At the end of the second phase, the MIDDS will be fully supporting the missions of the CCFF, but will not have the necessary operational reliability.

The third phase will consist of procuring the redundancy necessary for a fully reliable system. It provides the hardware and procedures necessary to have the system certified for full operational use. The operational system will have two embedded computers, each ingesting and preprocessing all of the data sources. This will allow almost instant recovery from any computer or ingest failures.

As is evident from the previous discussion on MIDDS development, the MIDDS will be a continually evolving system. System improvements will be largely governed by the requirements and funding of the NASA/USAF user community. System growth will be managed such that future users will be able to benefit from the foundation built by previous users. Consequently, the planned system benefits from both previous and future SSEC developments by being able to quickly and inexpensively incorporate them into the operational arena. These evolutionary developments will not only make for a better system at the CCFF, but will also support the development of an improved system for other interrelated users.

SUMMARY

MIDD\$ represents a major step toward providing the USAF weather forecasters a truly interactive, information-handling and display system. It will allow the forecasters to display and analyse satellite data on a near real time basis and to ingest and integrate many of the unique data sets found on the Eastern Test Range. This accelerates and enhances the assimilation and interpretation process. It is cost-effective because most hardware and software development costs have already been incurred on previous government contracts. Since the major development work and field testing have already been done, the system can be assembled from off-the-shelf components and delivered within a few months. Only minor fabrication and software adaptation will be needed. Particularly important is that the concept for MIDD\$ is of proven design and has demonstrated operational usefulness at the National Severe Storms Forecast Center. Another valuable feature is that MIDD\$ can accommodate additional data sources and application software as they become available. It provides a state-of-the-art meteorological information system and a technological foundation for future growth and technology transfer.